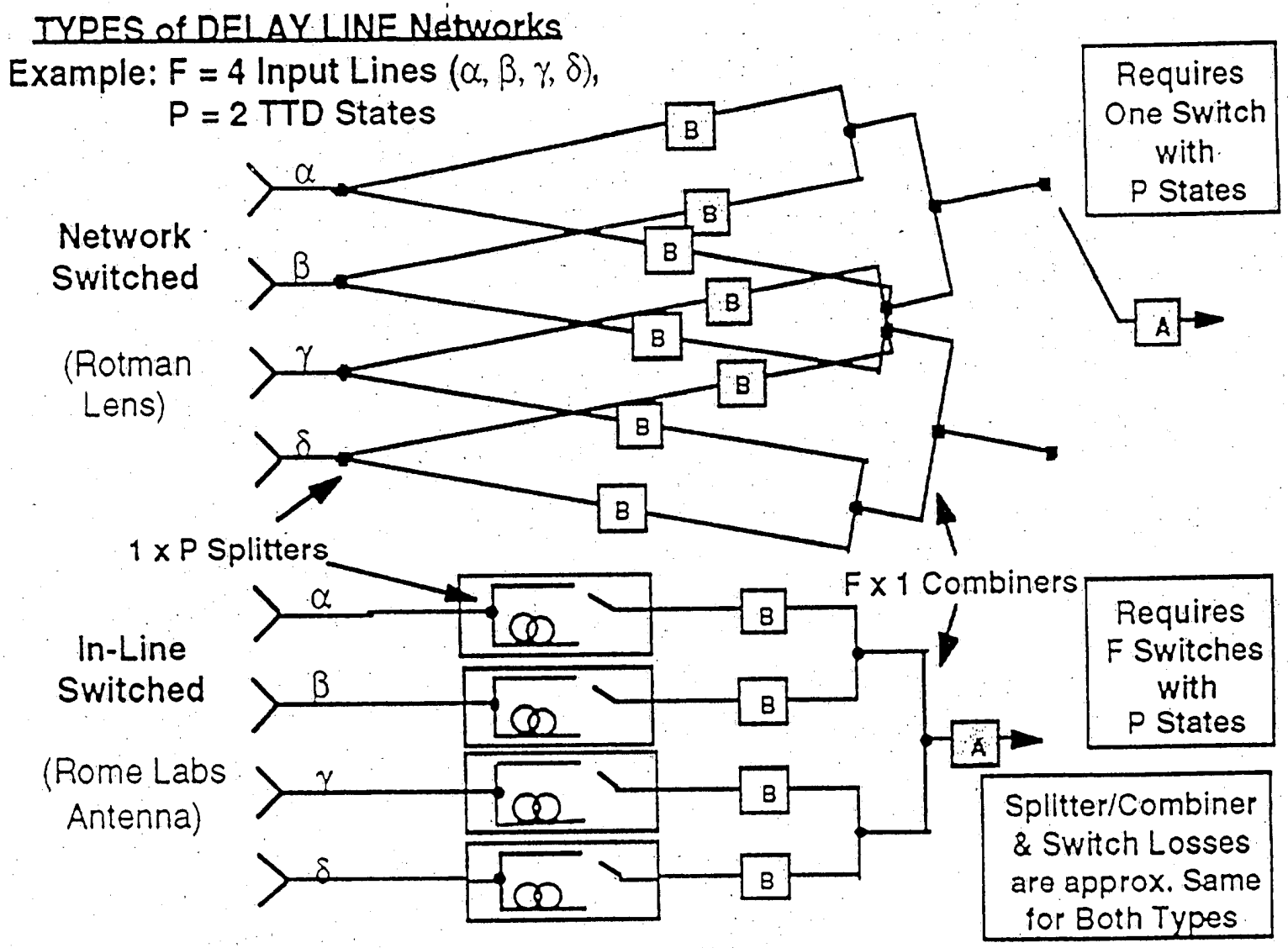


Fig. 1a

Fig 1b

PRIOR ART

EV258281415US

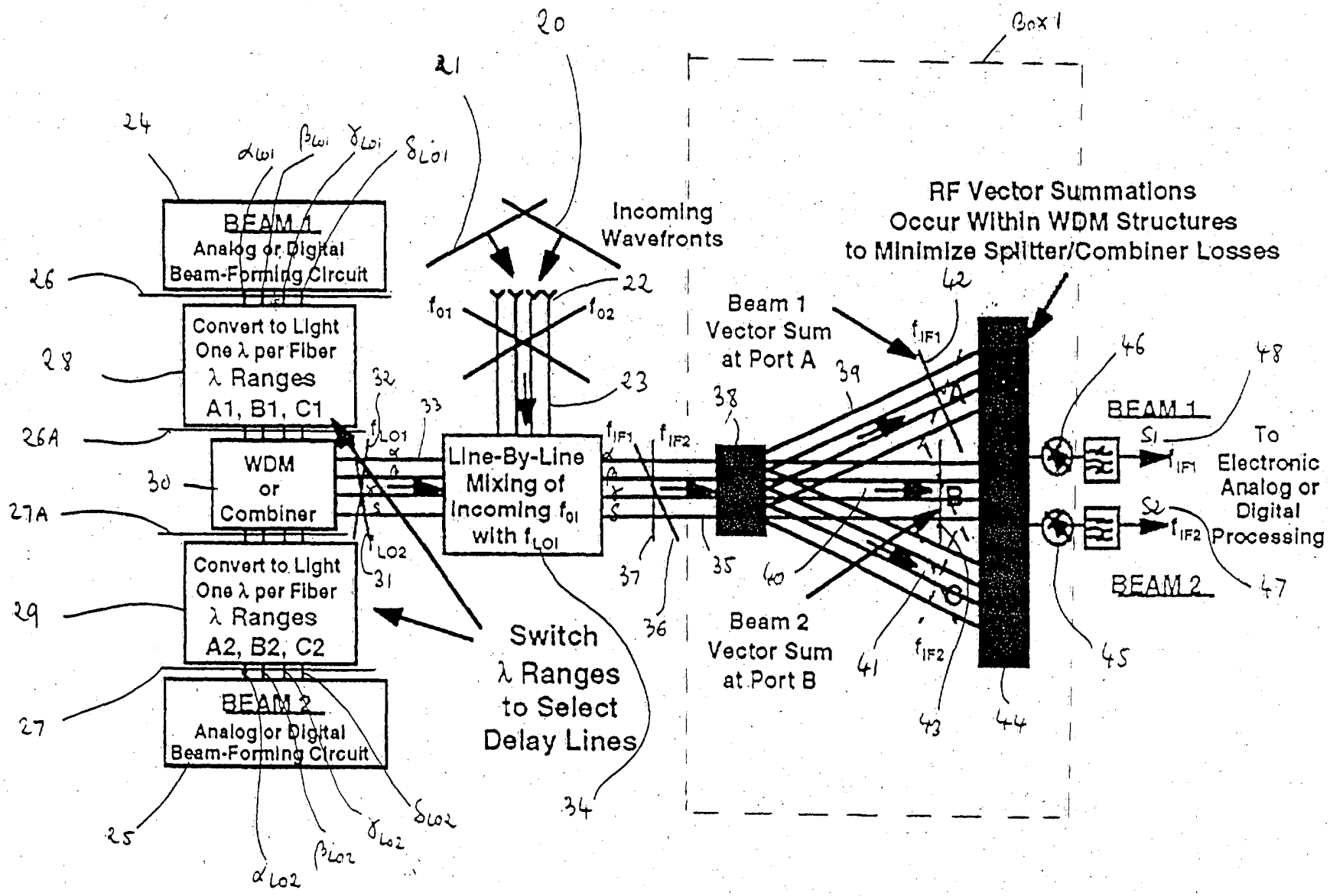

Box 1
20
21
24
BEAM 1
Analog or Digital
Beam-Forming Circuit
26
Convert to Light
One λ per Fiber
λ Ranges
A1, B1, C1
28
26A
WDM
or
Combiner
30
27A
Convert to Light
One λ per Fiber
λ Ranges
A2, B2, C2
29
BEAM 2
Analog or Digital
Beam-Forming Circuit
27
25
Incoming
Wavefronts
22
23
Line-By-Line
Mixing of
Incoming f_{01}
with f_{LO1}
Switch
λ Ranges
to Select
Delay Lines
34
RF Vector Summations
Occur Within WDM Structures
to Minimize Splitter/Combiner Losses
Beam 1
Vector Sum
at Port A
Beam 2
Vector Sum
at Port B
42
46
48
BEAM 1
S1
To
Electronic
Analog or
Digital
Processing
S2
47
BEAM 2
45
44
43
41
40
39
38
37
36
35
32
33
31

Fig. 2

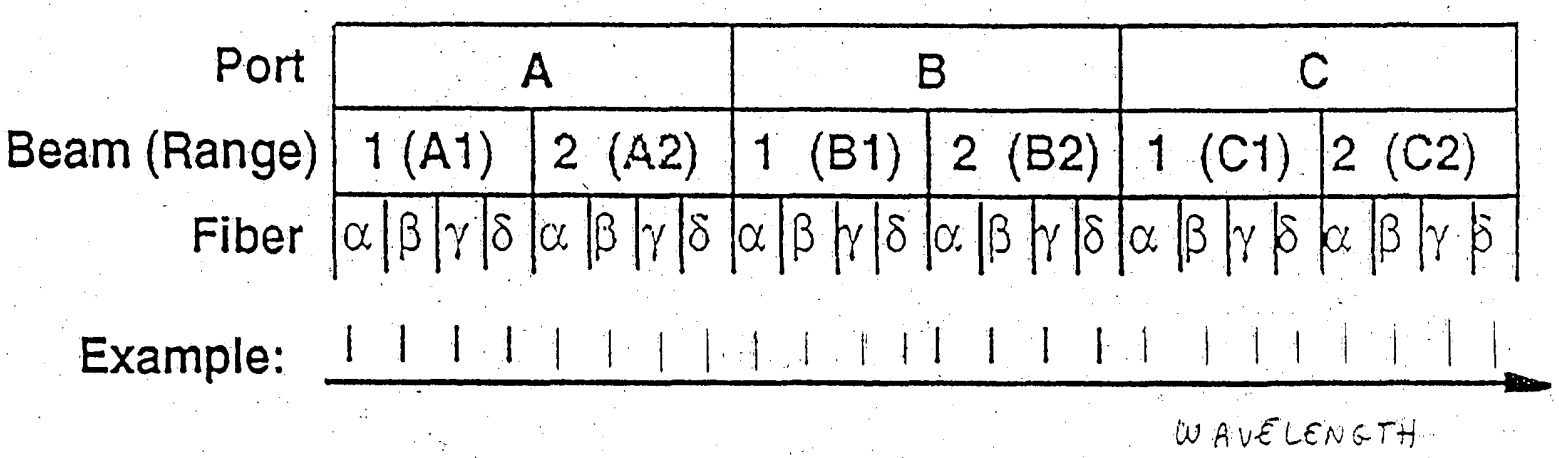

Port
A
B
C
Beam (Range)
1 (A1)
2 (A2)
1 (B1)
2 (B2)
1 (C1)
2 (C2)
Fiber
α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ
Example:
WAVELENGTH

Fig. 3a

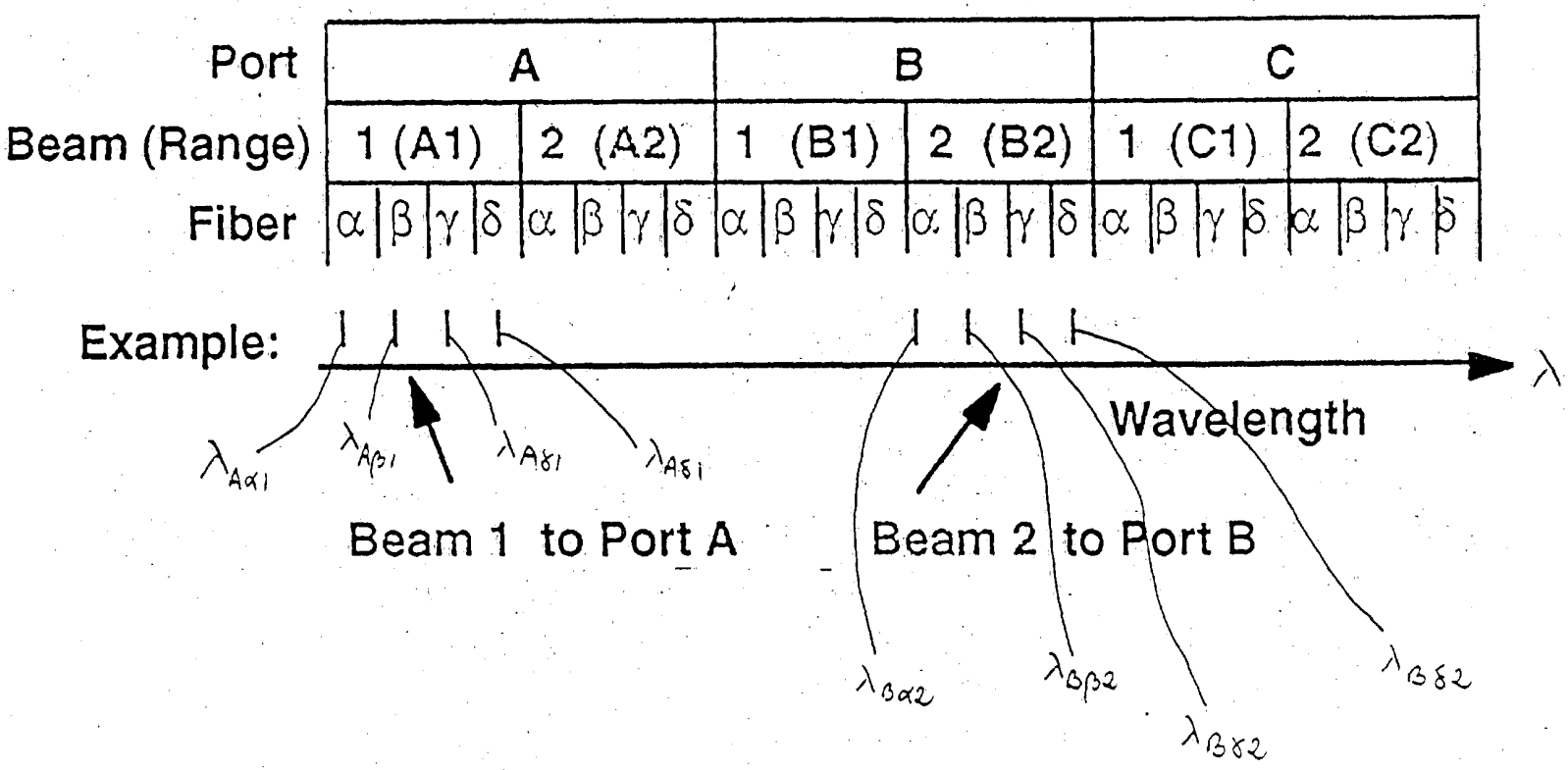

Port
A
B
C
Beam (Range)
1 (A1)
2 (A2)
1 (B1)
2 (B2)
1 (C1)
2 (C2)
Fiber
α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ α β γ δ
Example:
λ
Wavelength
$\lambda_{A\alpha 1}$
$\lambda_{A\beta 1}$
$\lambda_{A\delta 1}$
$\lambda_{A\delta 1}$
Beam 1 to Port A
Beam 2 to Port B
$\lambda_{B\alpha 2}$
$\lambda_{B\beta 2}$
$\lambda_{B\delta 2}$
$\lambda_{B\delta 2}$

Fig. 3b

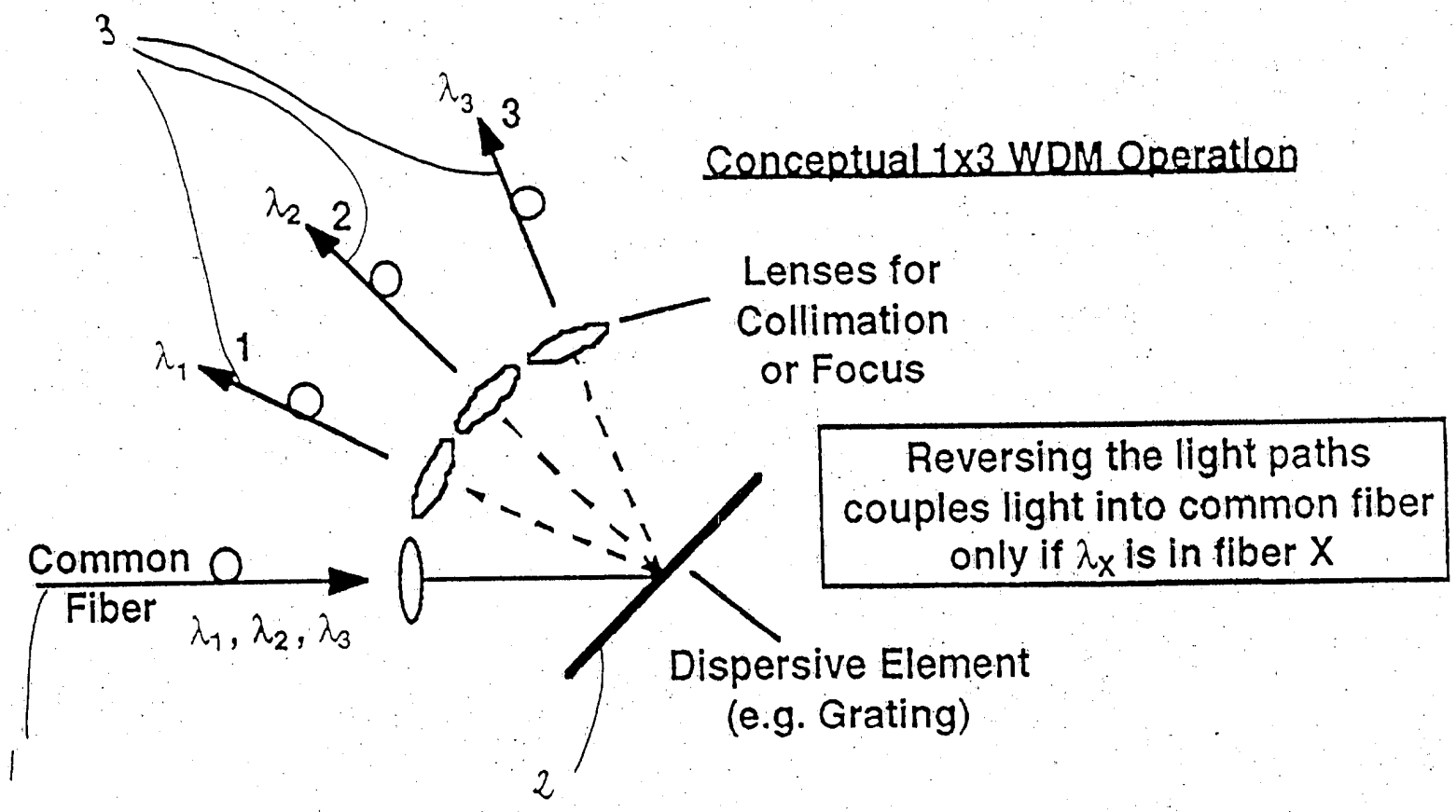

3
λ_3 3
Conceptual 1x3 WDM Operation
λ_2 2
Lenses for
Collimation
or Focus
λ_1 1
Reversing the light paths
couples light into common fiber
only if λ_X is in fiber X
Common
Fiber
$\lambda_1, \lambda_2, \lambda_3$
Dispersive Element
(e.g. Grating)
1
2

Fig. 4

Fig. 5

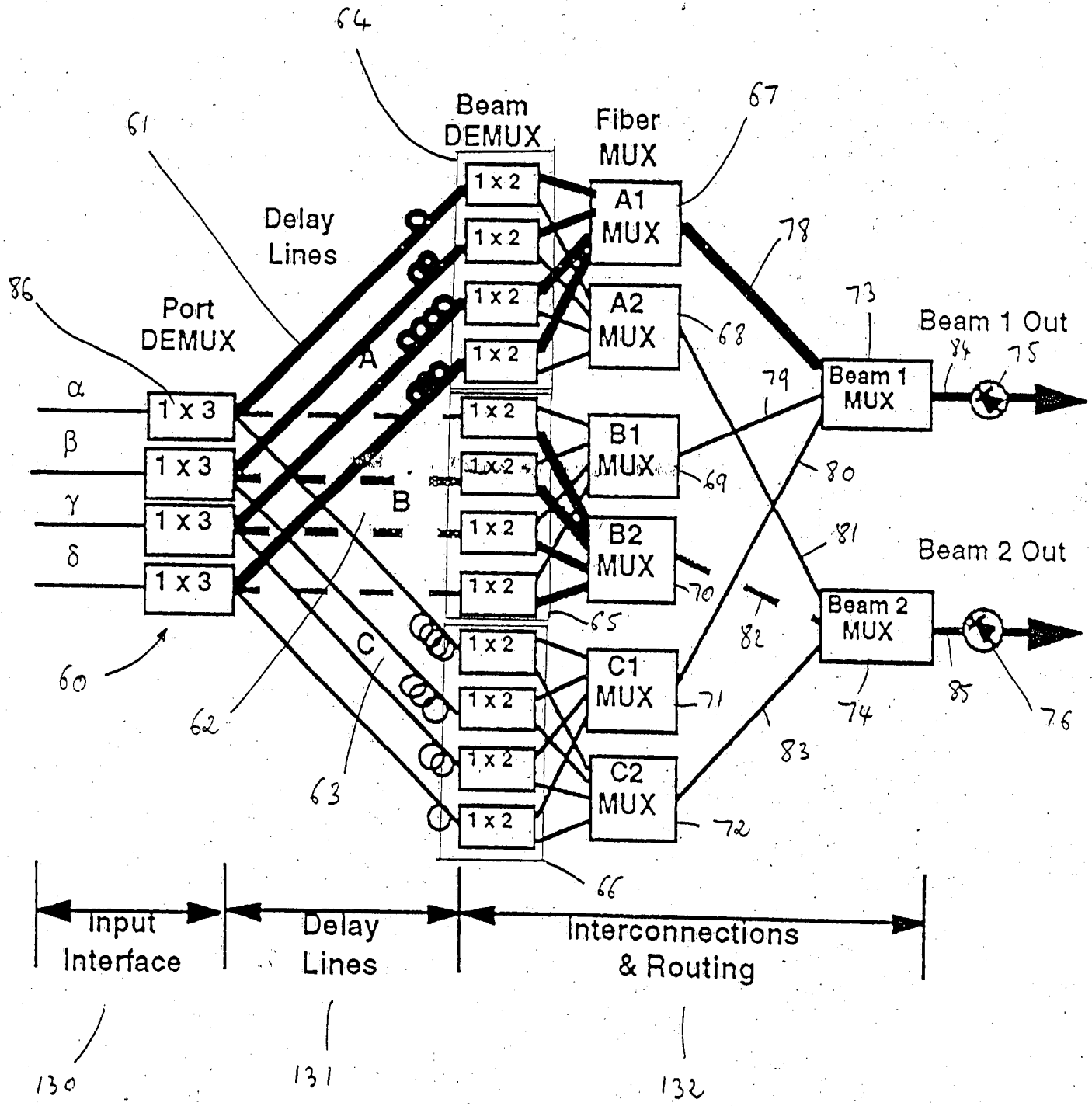
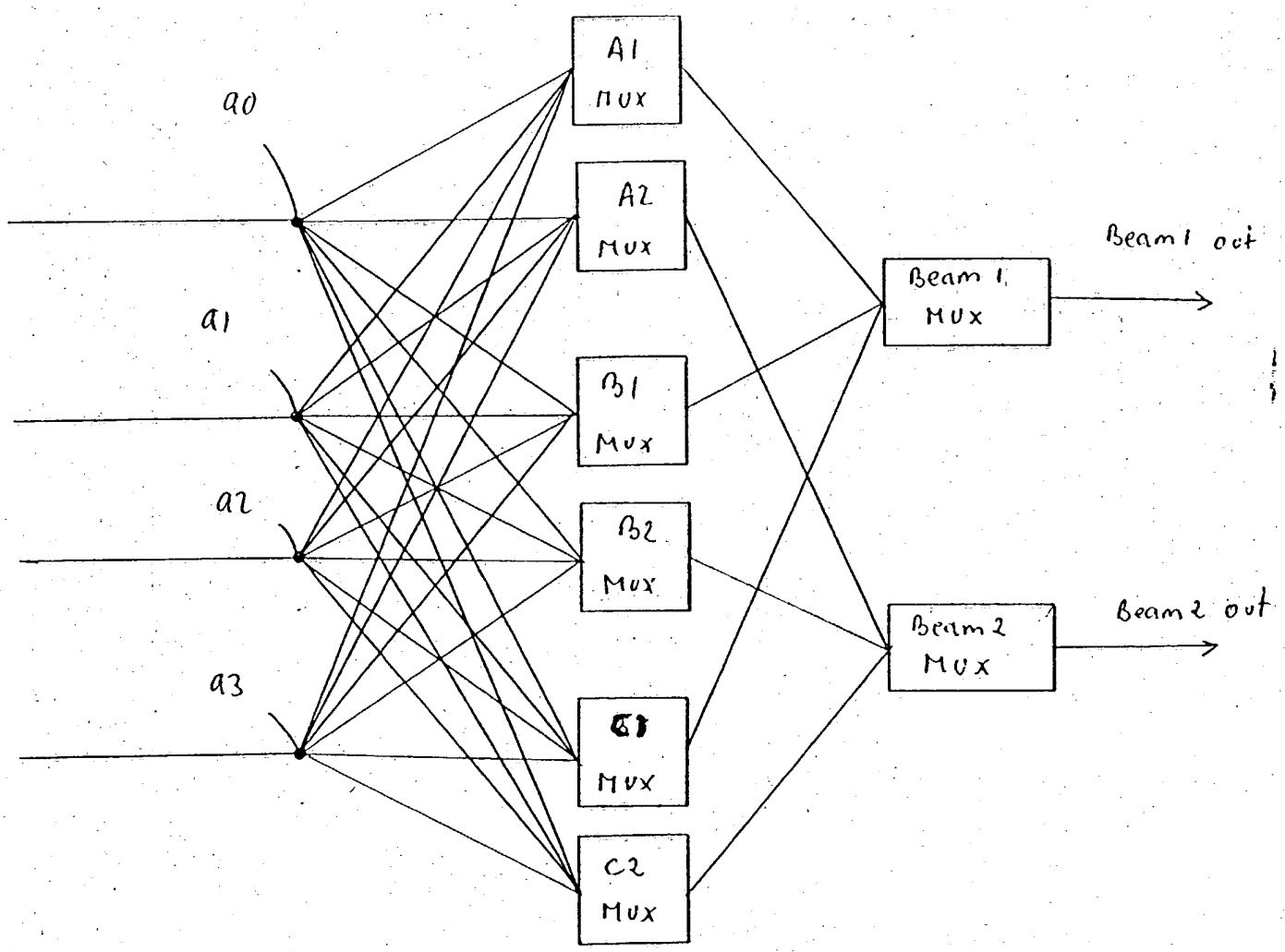

64
61
Beam DEMUX
Fiber MUX
67
Delay Lines
78
86
Port DEMUX
73
Beam 1 Out
84
75
A
α
1 x 3
β
1 x 3
γ
1 x 3
δ
1 x 3
1 x 2
A1 MUX
A2 MUX
68
79
Beam 1 MUX
B
B1 MUX
69
80
B2 MUX
70
81
Beam 2 Out
65
82
Beam 2 MUX
C
C1 MUX
71
74
85
76
C2 MUX
72
83
60
62
63
66
Input Interface
Delay Lines
Interconnections & Routing
130
131
132

Fig. 6


a0
a1
a2
a3
A1 MUX
A2 MUX
B1 MUX
B2 MUX
C1 MUX
C2 MUX
Beam 1 MUX
Beam 2 MUX
Beam 1 out
Beam 2 out

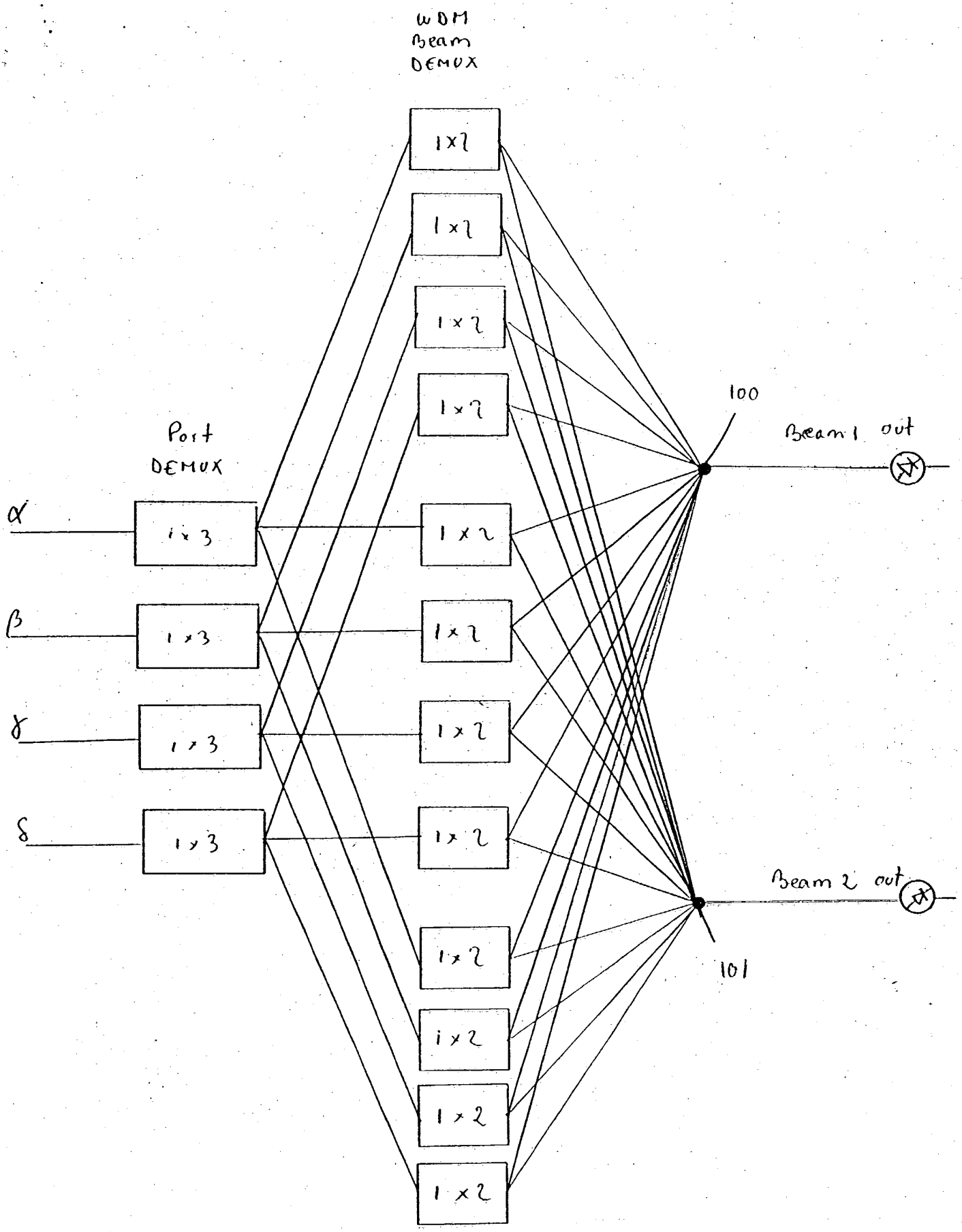

WDM
Beam
DEMUX
1×7
1×7
1×7
1×7
1×2
1×2
1×2
1×2
1×2
1×2
1×2
1×2
Port
DEMUX
1×3
1×3
1×3
1×3
α
β
γ
δ
100
101
Beam 1 out
Beam 2 out

Fig. 7

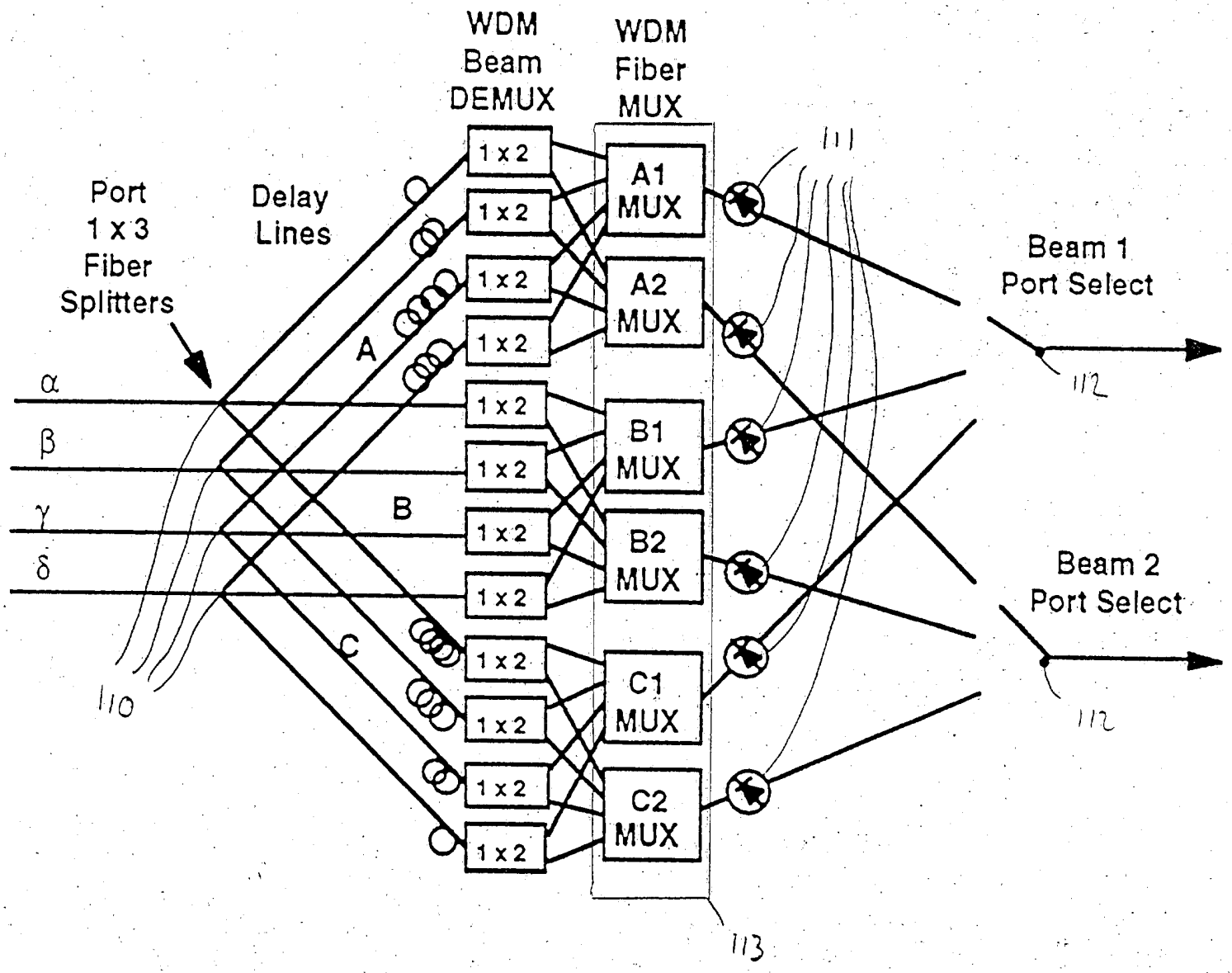

WDM
Beam
DEMUX
WDM
Fiber
MUX
Port
1 x 3
Fiber
Splitters
Delay
Lines
α
β
γ
δ
A
B
C
1 x 2
A1
MUX
A2
MUX
B1
MUX
B2
MUX
C1
MUX
C2
MUX
Beam 1
Port Select
Beam 2
Port Select
110
111
112
113

Fig. 8

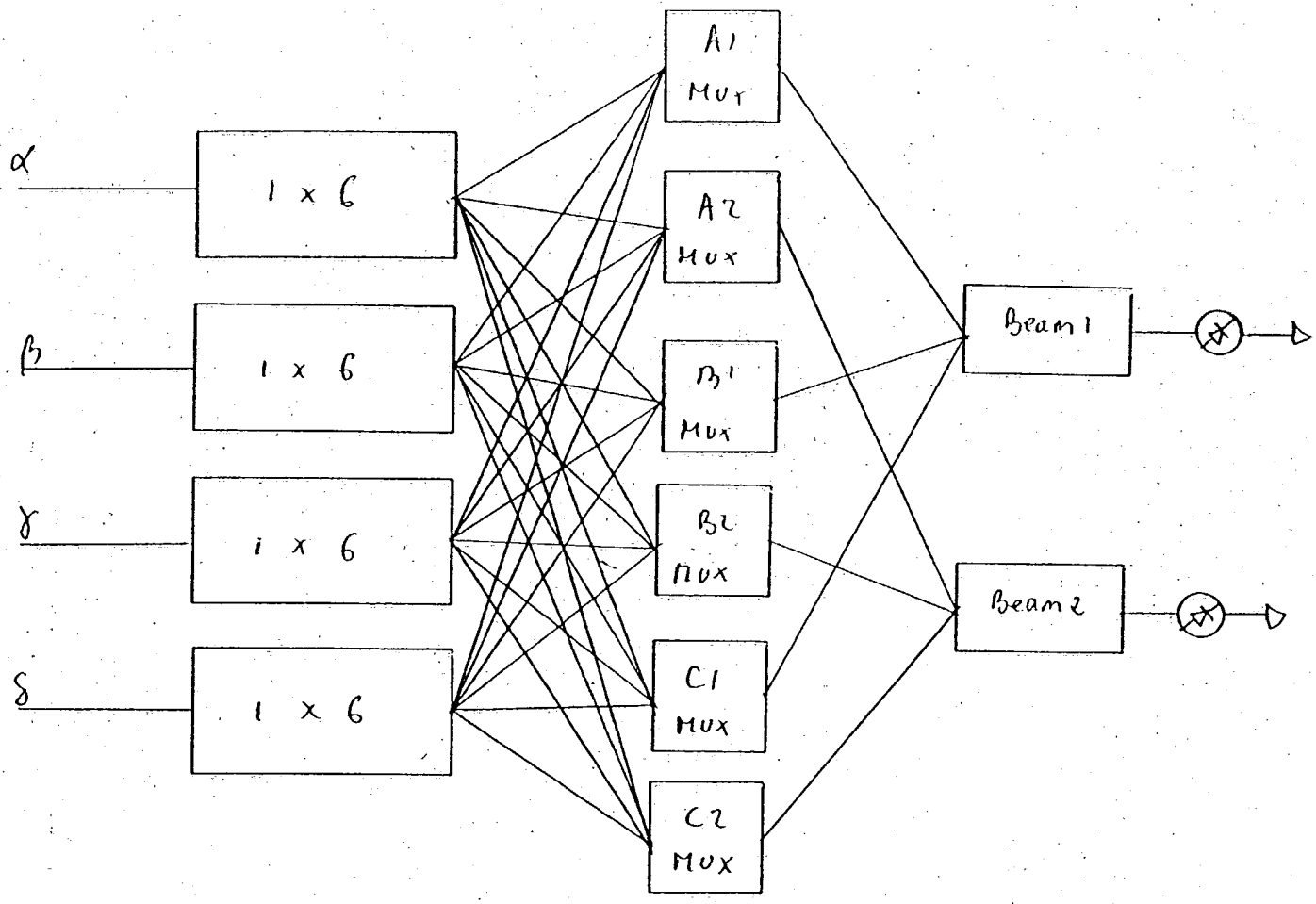

α
β
γ
δ
1 x 6
1 x 6
1 x 6
1 x 6
A1 Mux
A2 Mux
B1 Mux
B2 Mux
C1 Mux
C2 Mux
Beam 1
Beam 2

Fig. 9

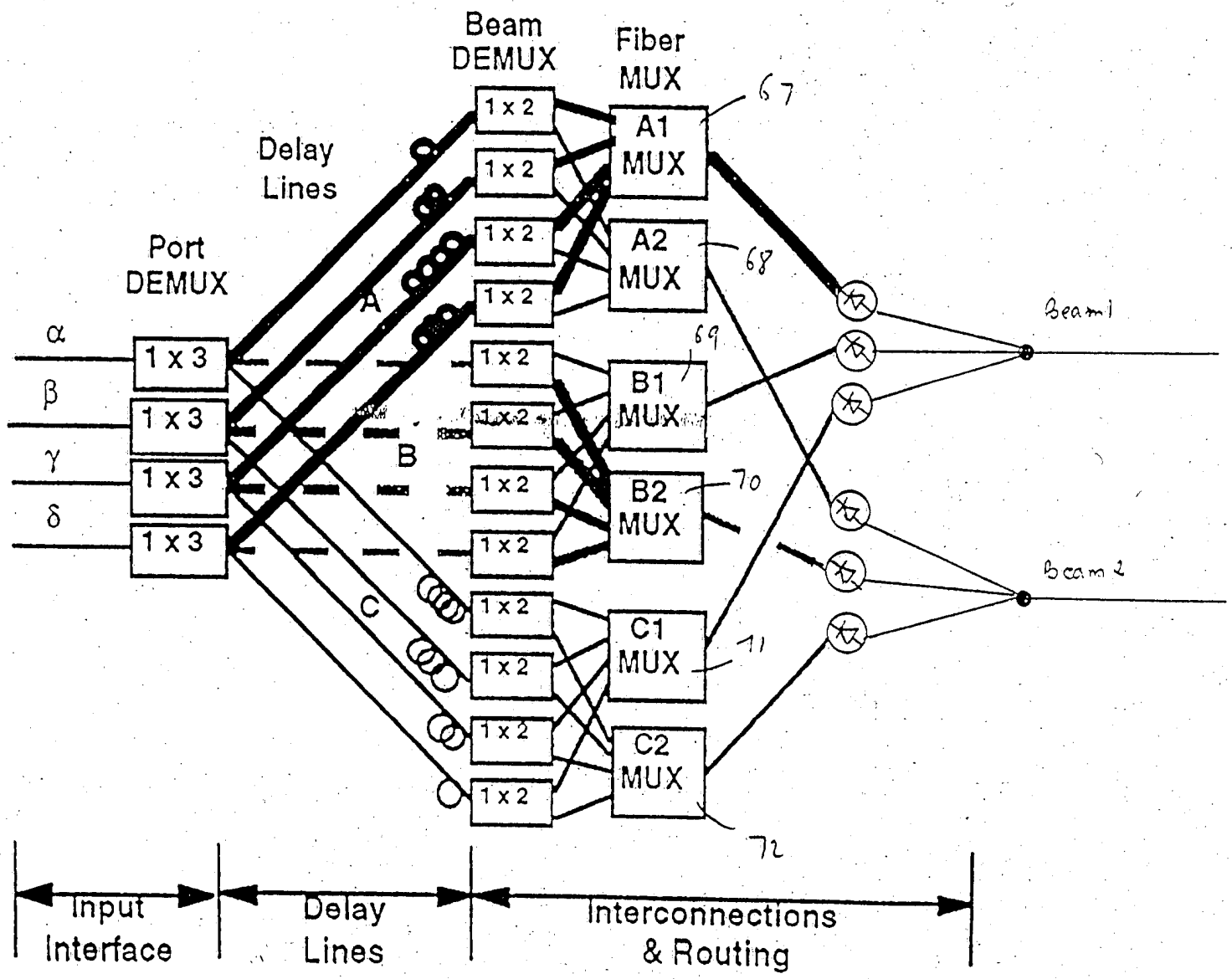

Beam DEMUX
Fiber MUX
Delay Lines
Port DEMUX
α
β
γ
δ
1 x 3
1 x 2
A
B
C
A1 MUX
A2 MUX
B1 MUX
B2 MUX
C1 MUX
C2 MUX
67
68
69
70
71
72
Beam 1
Beam 2
Input Interface
Delay Lines
Interconnections & Routing

Fig. 10

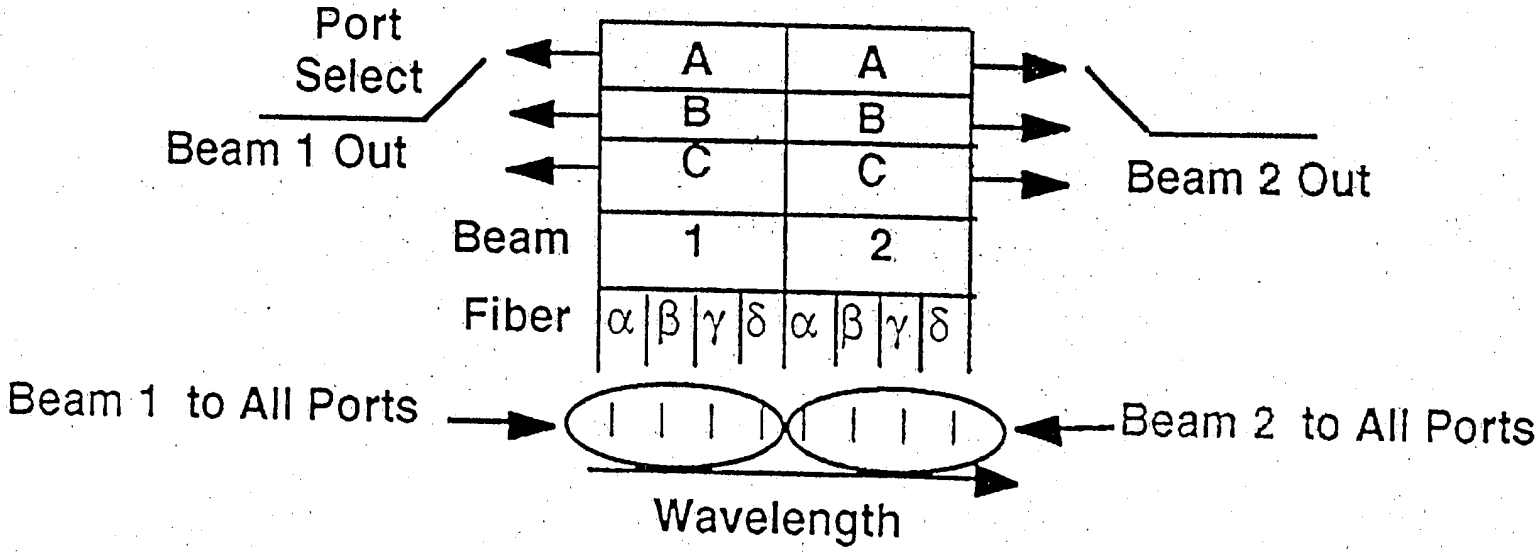

Port
Select
Beam 1 Out
A
A
B
B
C
C
Beam 2 Out
Beam
1
2
Fiber
α β γ δ α β γ δ
Beam 1 to All Ports
Beam 2 to All Ports
Wavelength

Fig. 11

Fiber Connections in 2-D Network Switched Delay Lines (Fiber Rotman Lens)

Port Connections for One Fiber in Array

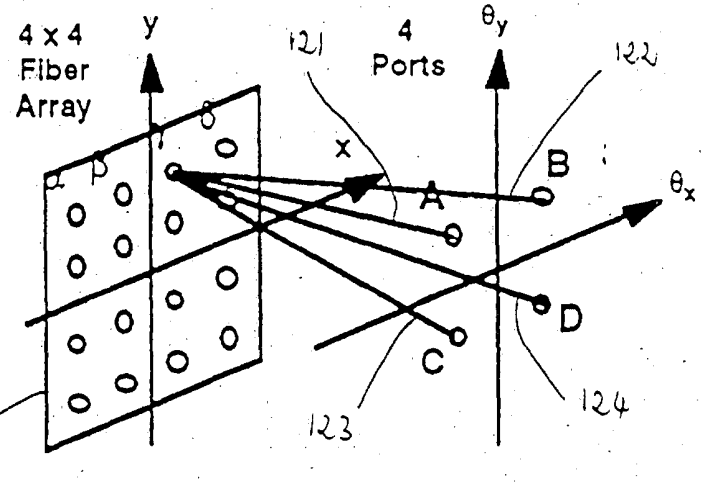


Fig. 12a

Connections to Fiber Array for One Rotman Port

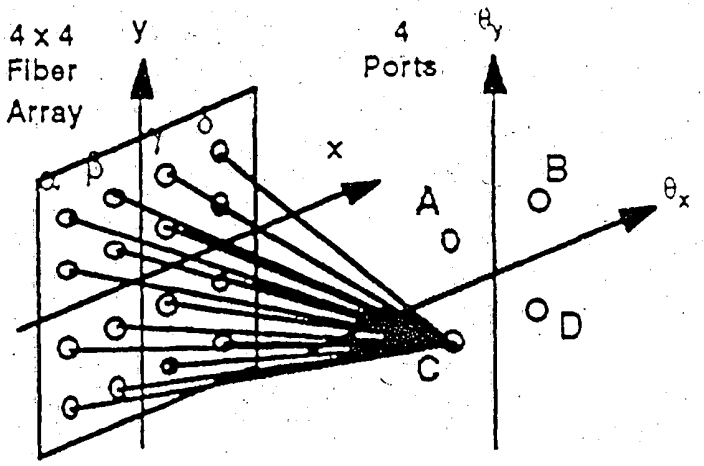


Fig. 12b

For a given port, the delay paths differ by ΔL_x and ΔL_y while passing from fiber to fiber in the array

$$\Delta L_x = (Dv/c)\sin\theta_x, \quad \Delta L_y = (Dv/c)\sin\theta_y$$

D = Antenna element spacing
v = Light velocity in delay line
c = Light velocity in vacuum
θ_x, θ_y = x, y components of delay line scan angle

125

Fig. 12

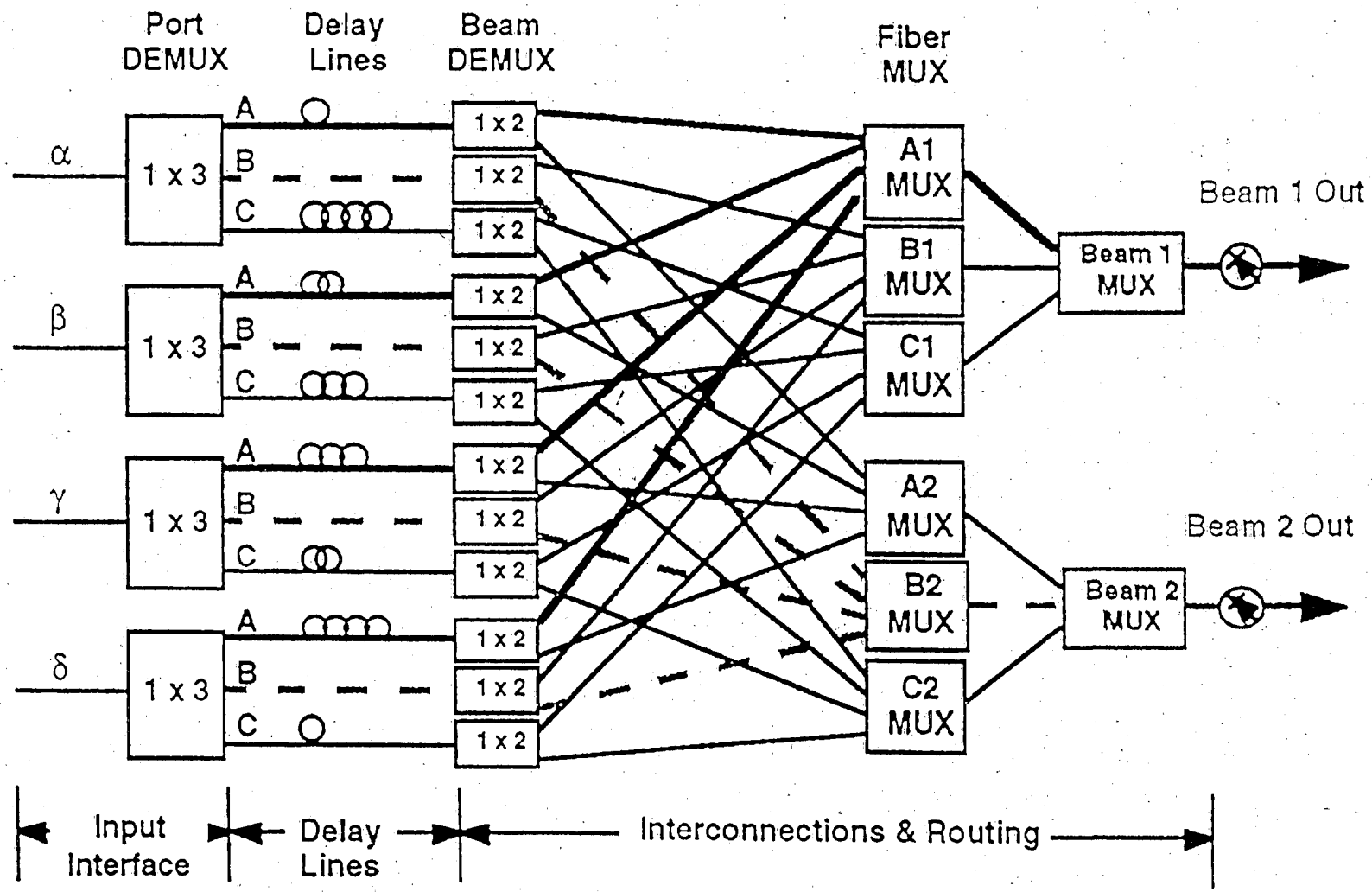

Port DEMUX
Delay Lines
Beam DEMUX
Fiber MUX
α
β
γ
δ
1 x 3
A
B
C
1 x 2
A1 MUX
B1 MUX
C1 MUX
A2 MUX
B2 MUX
C2 MUX
Beam 1 MUX
Beam 2 MUX
Beam 1 Out
Beam 2 Out
Input Interface
Delay Lines
Interconnections & Routing

Fig. 13

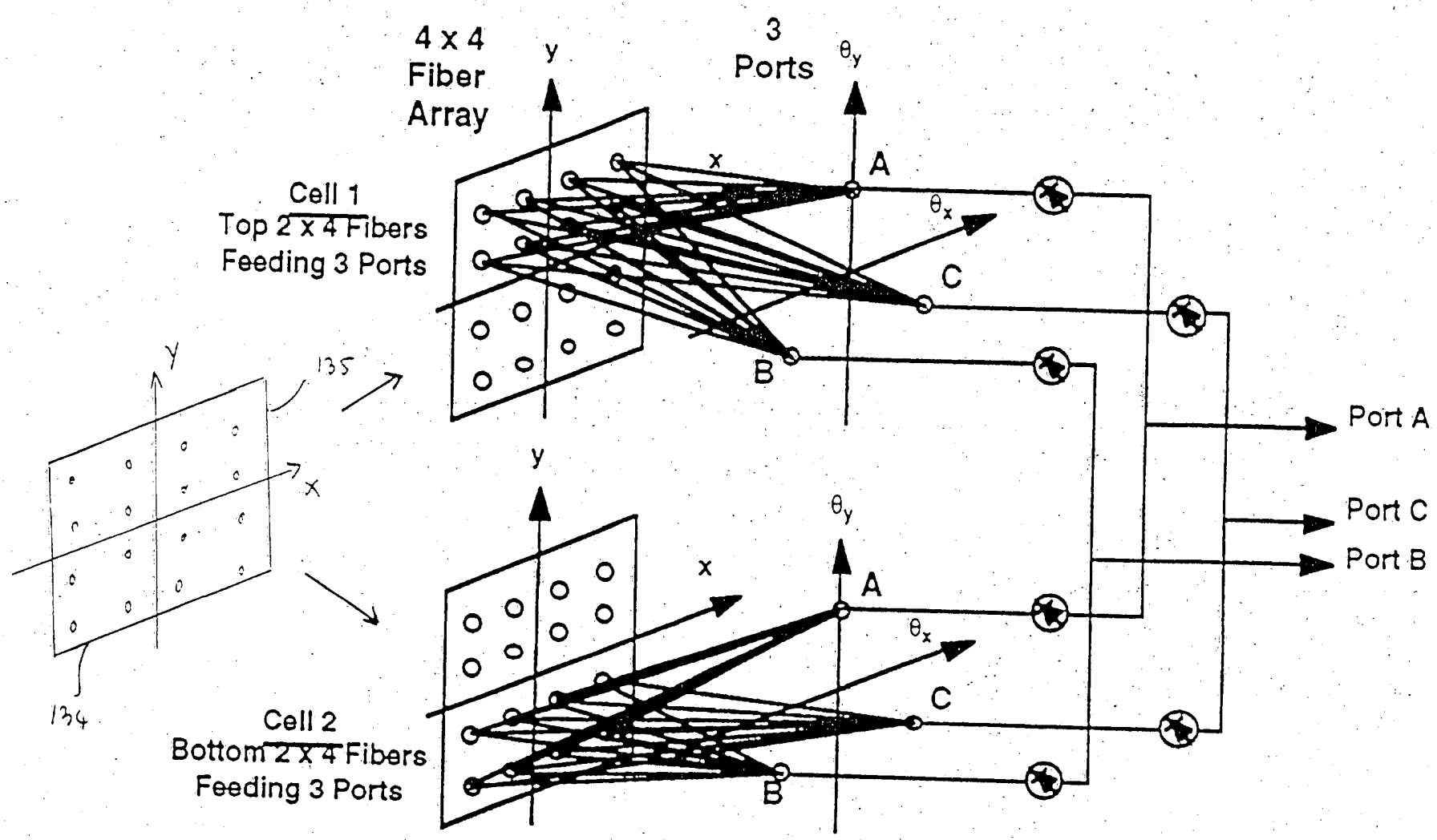

4 x 4
Fiber
Array
3
Ports
y
θ_y
x
A
θ_x
C
B
Cell 1
Top 2 x 4 Fibers
Feeding 3 Ports
135
134
Cell 2
Bottom 2 x 4 Fibers
Feeding 3 Ports
Port A
Port C
Port B

Fig. 14

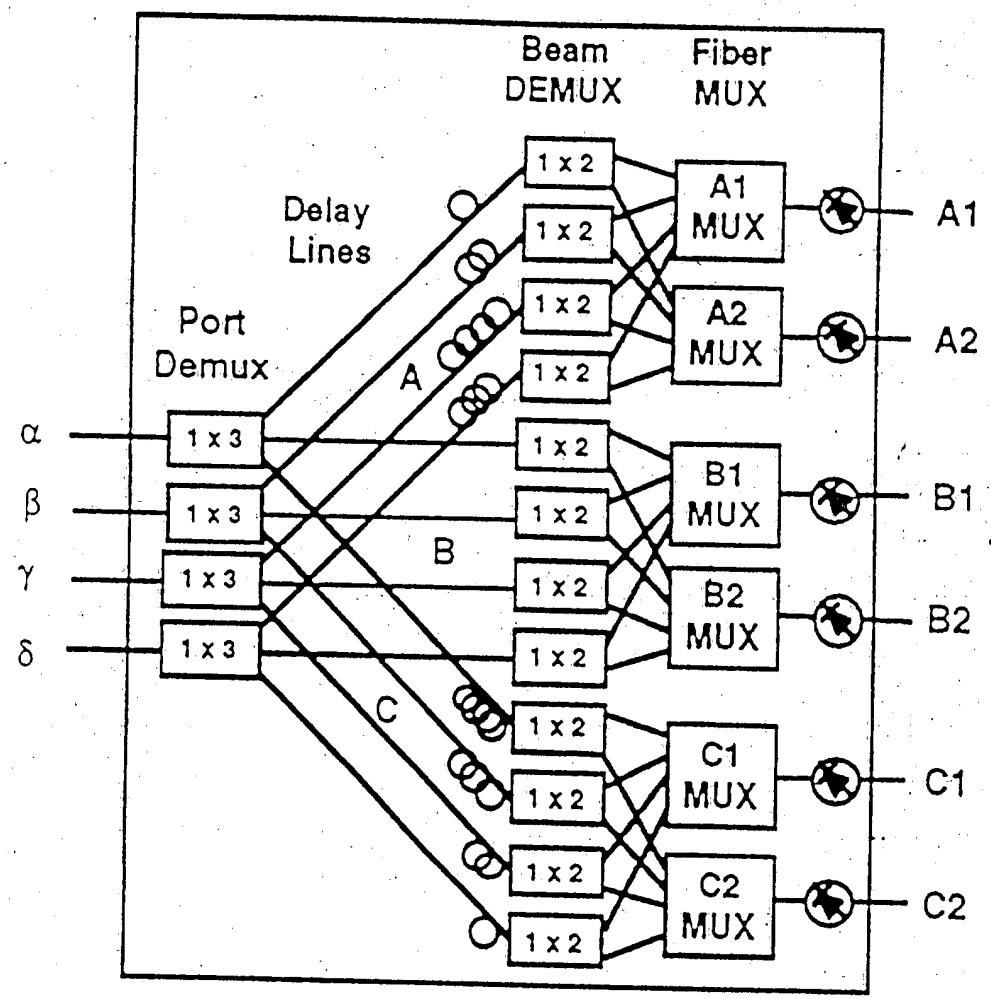


Fig. 15a

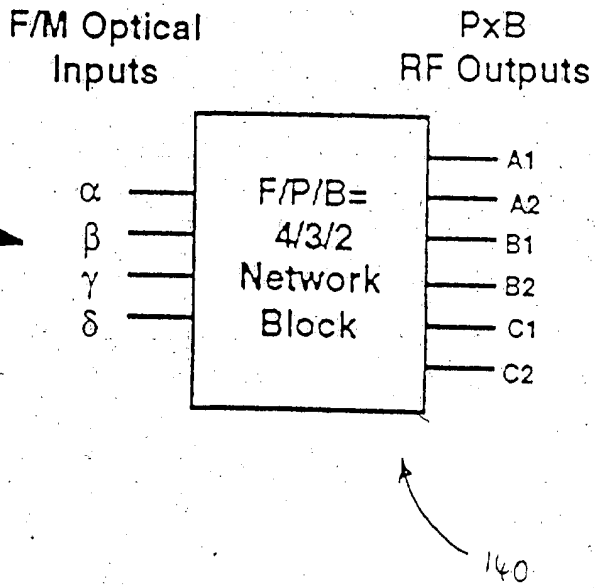


Fig. 15b

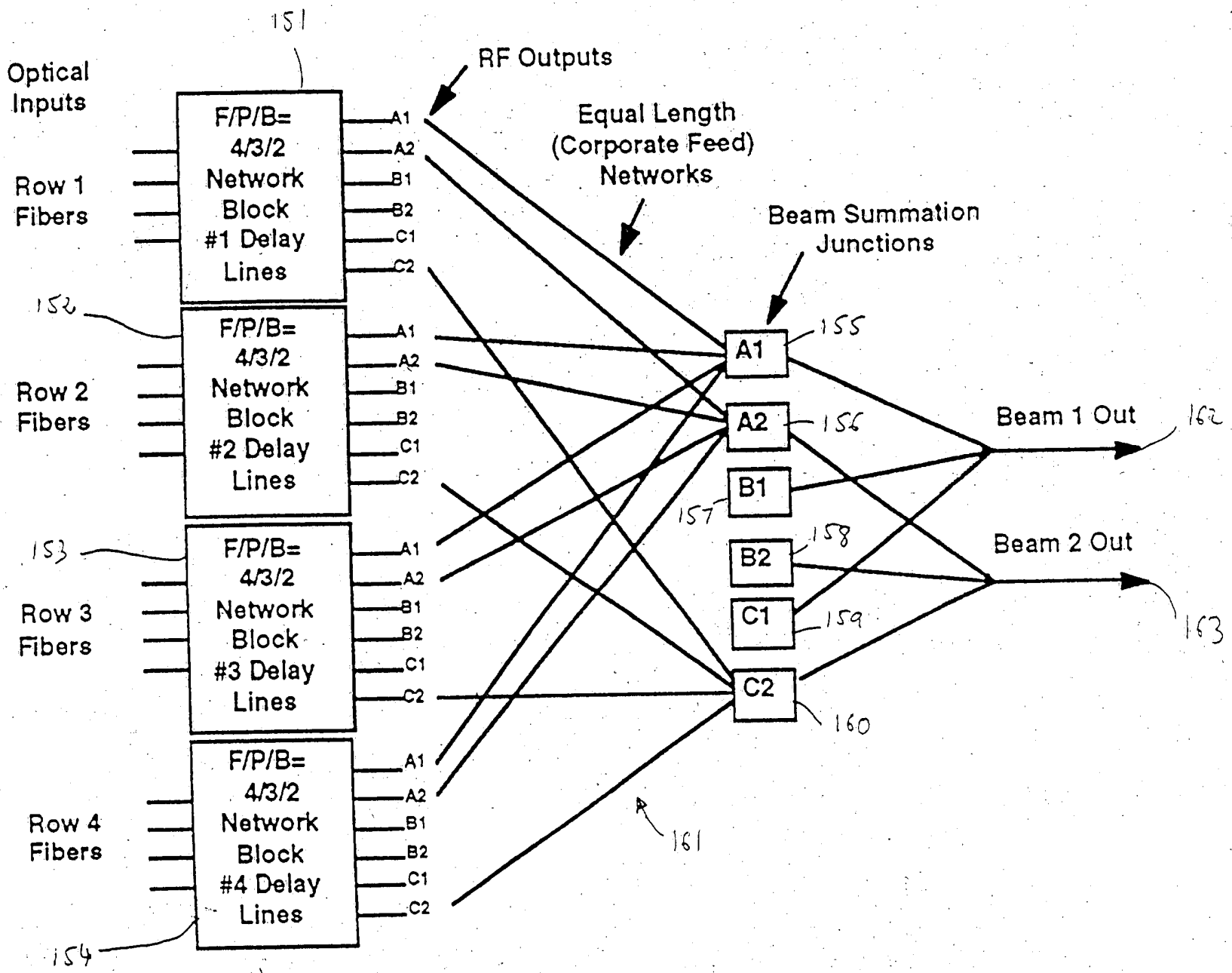

151
Optical Inputs
RF Outputs
Equal Length (Corporate Feed) Networks
Beam Summation Junctions
F/P/B= 4/3/2 Network Block #1 Delay Lines
Row 1 Fibers
F/P/B= 4/3/2 Network Block #2 Delay Lines
Row 2 Fibers
F/P/B= 4/3/2 Network Block #3 Delay Lines
Row 3 Fibers
F/P/B= 4/3/2 Network Block #4 Delay Lines
Row 4 Fibers
A1
A2
B1
B2
C1
C2
152
153
154
155
156
157
158
159
160
161
162
163
Beam 1 Out
Beam 2 Out

Fig. 16

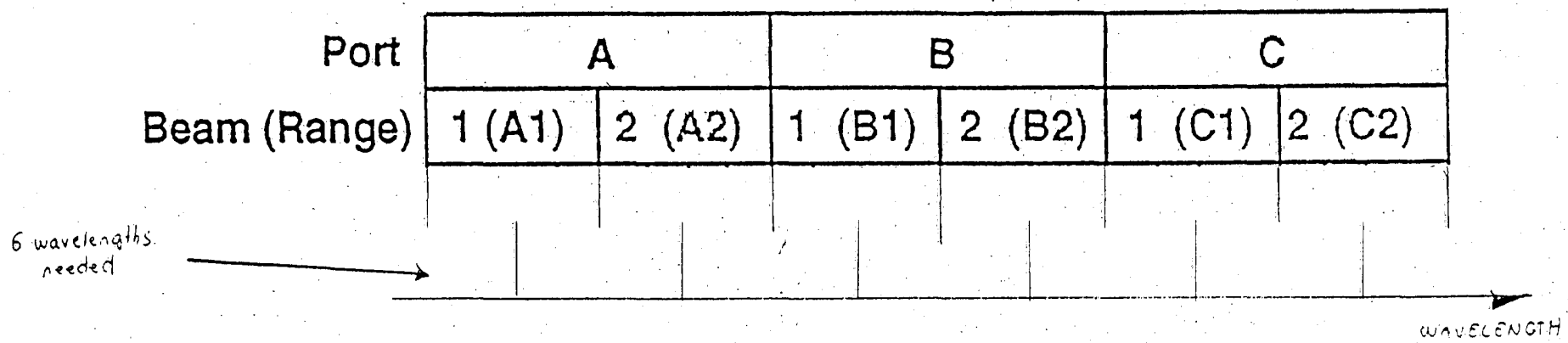

Port
A
B
C
Beam (Range)
1 (A1)
2 (A2)
1 (B1)
2 (B2)
1 (C1)
2 (C2)
6 wavelengths needed
WAVELENGTH

Fig. 17

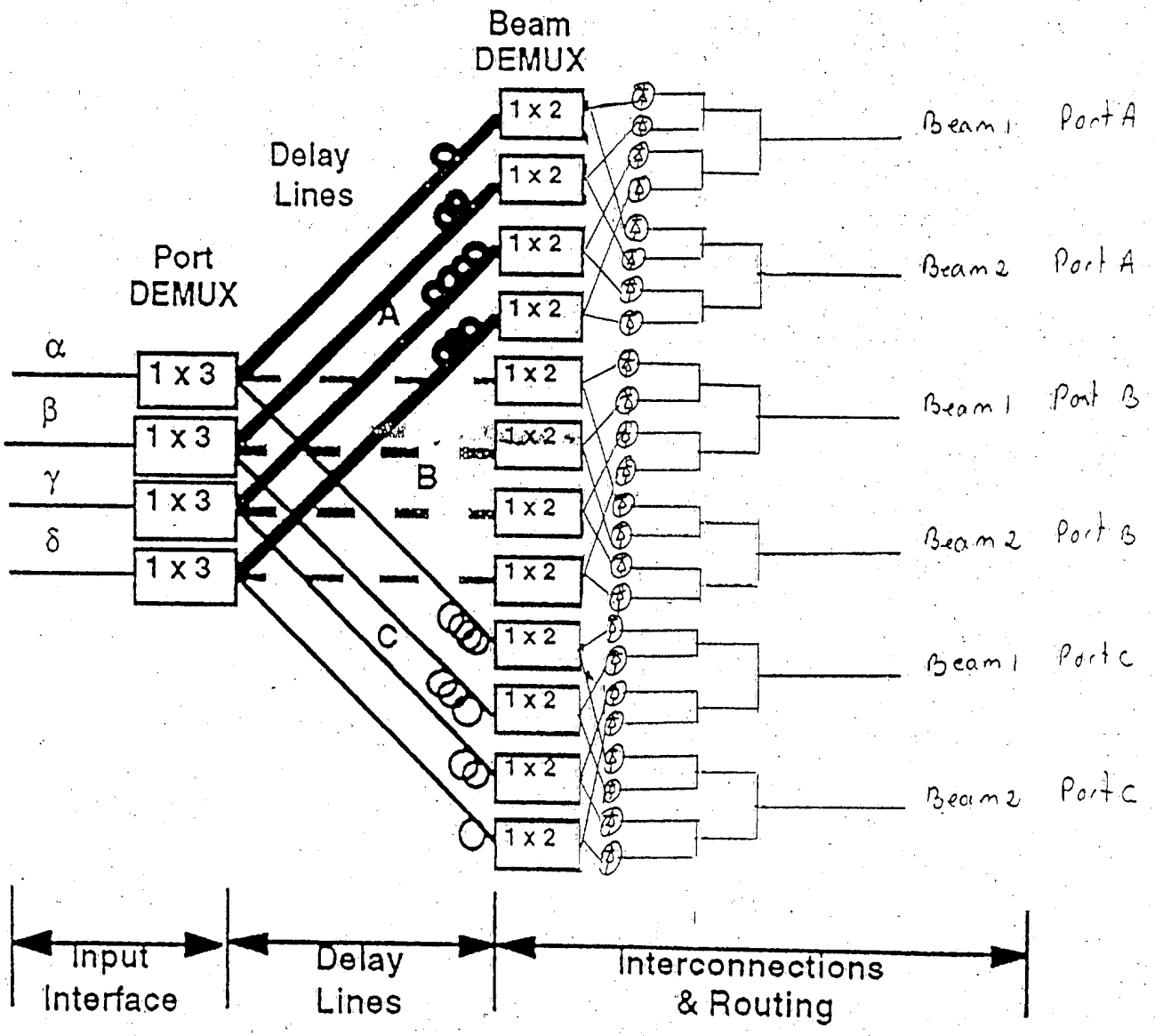

Beam
DEMUX
Delay
Lines
Port
DEMUX
α
β
γ
δ
1 x 3
1 x 3
1 x 3
1 x 3
A
B
C
1 x 2
Beam 1 Port A
Beam 2 Port A
Beam 1 Port B
Beam 2 Port B
Beam 1 Port C
Beam 2 Port C
Input
Interface
Delay
Lines
Interconnections
& Routing

Fig. 18

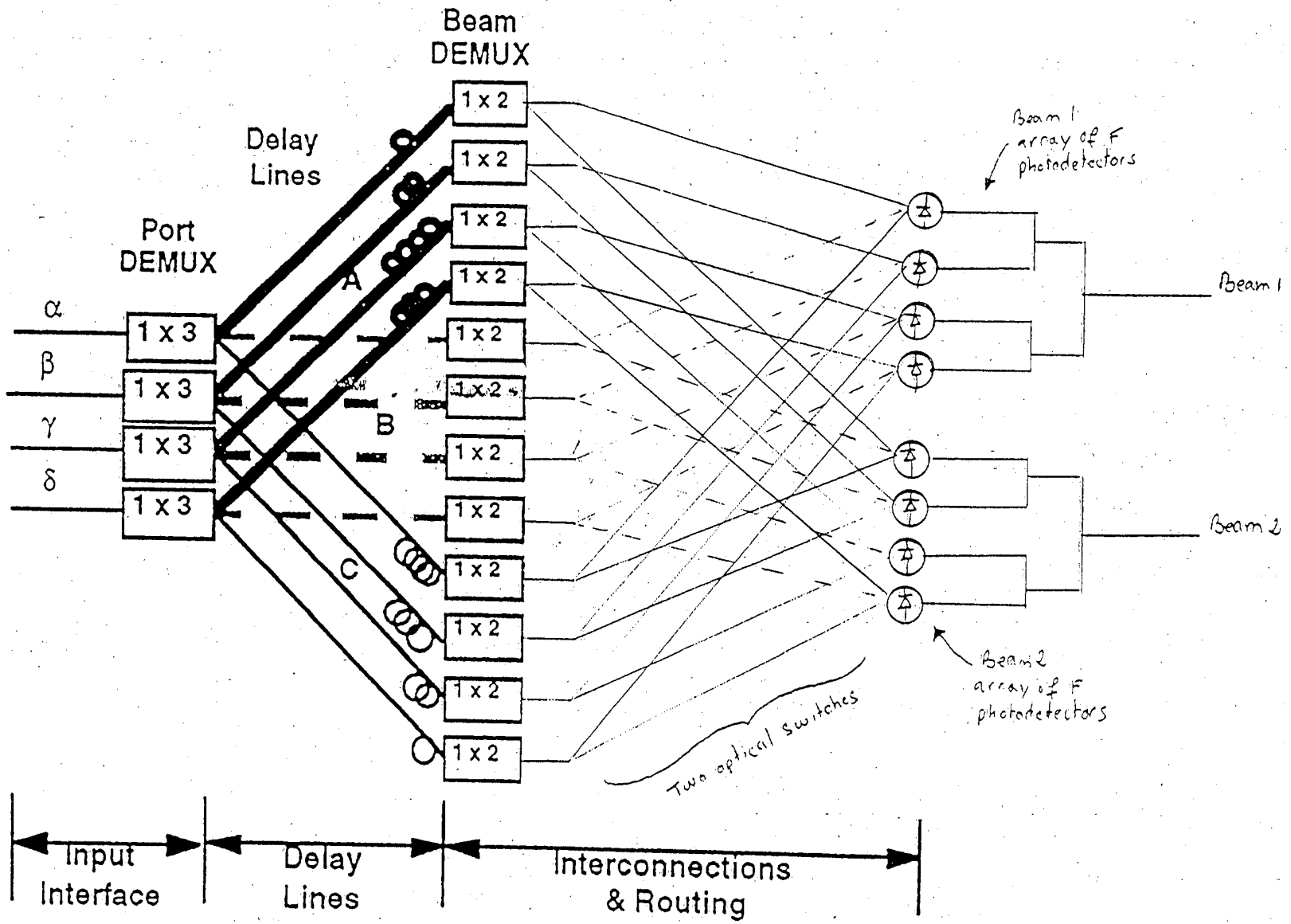

Beam DEMUX
Delay Lines
Port DEMUX
α
β
γ
δ
1 x 3
1 x 3
1 x 3
1 x 3
A
B
C
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
1 x 2
Beam 1 array of F photodetectors
Beam 1
Beam 2
Beam 2 array of F photodetectors
Two optical switches
Input Interface
Delay Lines
Interconnections & Routing

Fig. 19